

Interventional Spine Procedures for Management of Chronic Low Back Pain—A Primer

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Abstract

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Chronic low back pain is a common clinical condition. Percutaneous fluoroscopic-guided interventions are safe and effective procedures for the management of chronic low back pain, which can be performed in an outpatient setting. Interventional radiologists already possess the technical skills necessary to perform these interventions effectively so that they may be incorporated into a busy outpatient practice. This article provides a basic approach to the evaluation of patients with low back pain, as well as a review of techniques used to perform the most common interventions using fluoroscopic guidance.

Objectives: Upon completion of this article, the reader will be able to identify patients with centralized low back pain versus those with radiculopathy, and determine the most appropriate initial approach to percutaneous intervention using a variety of imaging-guided injection techniques.

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Acute low back pain is a common ailment in the United States, estimated to affect up to 80% of individuals at some

point in their lives, and causing significant disability in approximately 1 to 2% of the adult population. An estimated 12 to 15% of visits to health-care providers annually in the United States are related to low back pain.¹ The majority of patients who suffer an episode of acute low back pain experience symptom resolution spontaneously or with conservative measures only within 4 to 6 weeks. If symptoms persist, the likelihood of return to normal function diminishes rapidly regardless of the therapy chosen.

There are compelling data in the surgical literature suggesting efficacy of spinal fusion for degenerative spondylolisthesis, decompressive laminectomy for symptomatic spinal stenosis, and discectomy for acute radicular pain associated with a disc herniation in well-selected patients.^{2–6} Selecting appropriate patients for surgical therapy can be challenging, however. There may be considerable variability in diagnostic accuracy, and clinical and imaging findings do not always coincide. Results from surgical treatment can also vary, even in well-selected patients. It has been shown that many patients fare equally well long term with conservative

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management.^{7,8} Patients are also becoming more knowledgeable about the scope of available treatment options and, appropriately or not, may be skeptical about the role of surgery in the management of chronic low back pain (The Association of American Retired People [AARP] recently listed lumbar spine surgery on its Web site as one of five controversial surgeries to avoid).

A primary goal in the management of chronic low back pain may be temporary alleviation of pain to enable the patient to become fully engaged in a physical therapy and rehabilitation program aimed at improving strength and body mechanics to minimize physical stress and provide more long-term relief.⁹ Patients who may benefit from minimally invasive injection treatments are those who lack a strong indication for surgery, are inappropriate surgical candidates due to age or medical comorbidities, or cannot tolerate oral pain medications in dosages necessary to control their symptoms.

This article provides a basic approach to the evaluation of patients with low back pain, as well as a review of techniques used to perform the most common treatments under fluoroscopic guidance.

Evaluation of the Patient with Low Back Pain

Patients who may benefit from image-guided injections for lower back pain are those who have had symptoms for at least 6 weeks with inadequate response to conservative treatment measures such as physical therapy, exercise therapy, heat therapy, massage therapy, anti-inflammatory or antispasmodic medications, and/or narcotic analgesics. Patients who are significantly debilitated or unable to fully participate in physical therapy and rehabilitation due to limitations posed by pain should also be considered for intervention.

Prior to intervention, all patients should be clinically evaluated in formal consultation in the office setting. Complete evaluation should include a history of the presenting complaint, physical/neurologic examination, and review of any available up-to-date imaging of the spine in the region of interest. Although pretreatment imaging is not essential, it may be helpful to exclude causes of back pain such as fracture, infection, or malignancy in cases where clinical suspicion may be present. The consultation visit should facilitate treatment planning, enhance patient understanding regarding the overall treatment plan, and establish reasonable expectations regarding treatment outcome and long-term goals.

Ascertaining the specific cause of chronic low back pain can be difficult, as most cases are likely to be multifactorial. Any anatomic structure that is innervated by pain fibers is capable of producing pain, and in the spine, this includes facet joints, intervertebral discs, nerve roots, ligaments, and paraspinal muscles. Each of these structures, in turn, may be innervated by multiple spinal nerves, and disease affecting one structure may cause clinical symptoms that overlap considerably with those related to other surrounding structures. Neurologic examination may be helpful in cases of radicular pain, when compression of specific nerve roots leads to symptoms that can be localized to specific sensory

dermatomes. Even in such cases, description of the specific distribution of symptoms by the patient may be inaccurate, particularly if symptoms are intermittent. To further complicate the diagnosis, imaging studies are often unreliable—they may demonstrate little or no structural abnormality in symptomatic patients or significant disease in patients who are asymptomatic, and therefore cannot be used exclusively to localize a significant level of disease.

Given the inherent difficulty in establishing a definitive etiology for most cases of chronic low back pain, the basic approach to patient evaluation during the initial consultation visit should adhere to a basic clinical algorithm. The key to creating an appropriate treatment plan for all patients with chronic low back pain is to distinguish radicular or “peripheralized” pain from somatic or “centralized” pain.

Radicular Pain

Radicular pain radiates from the spine to a distal aspect of the lower extremity and is often described by the patient as a sensation of either “pins and needles,” sharp, shooting, or burning in quality. Its distribution conforms within reason to a known sensory dermatome. It may be associated with neurologic findings of weakness or other sensory disturbances. This pain is typically due to disc disease compressing specific nerve roots. Patients typically complain more of leg discomfort than back discomfort. On examination, straight-leg raise testing tends to be positive, and motor strength and deep tendon reflexes may be diminished in the affected extremity. This pain is typically worse with the stress of axial loading on the spine—after periods of prolonged sitting, forward flexion, lifting, twisting, and straining (such as during coughing or sneezing). Although symptoms may be similar, patients with *spinal stenosis* usually have classic neurogenic claudication, and pain is only relieved by sitting and forward flexion of the spine. Pain related to spinal nerve irritation or spinal stenosis is most appropriately treated with epidural steroid injection (ESI), with the goal of delivering the smallest amount of drug necessary as close as possible to the irritated nerve.

Somatic Pain

Somatic pain is usually centralized and does not have a classic radicular component. Although it can occasionally “radiate” into the lower extremities, it usually does so to a very limited extent without extending below the knee (usually in the buttocks/thighs) in a distribution that does not conform to any known sensory dermatome. Patients usually describe the pain as dull and achy in quality, and they typically complain more of back discomfort than leg discomfort. This type of pain is most suggestive of facet-mediated mechanical back pain and is commonly associated with paraspinal muscle spasms. Pain is exacerbated by spinal extension, as this typically places a greater load on the facet joints. Patients typically describe pain that is worse after periods of prolonged standing, and is exacerbated by spinal rotation, walking, and laying prone. It is often cyclic in quality—patients wake up with a “stiff back” which temporarily improves with activity but then gradually worsens throughout the day. Patients may

describe some relief with changes in position and when laying in the fetal position. They may demonstrate localized tenderness of the facet joints (most commonly at the lumbosacral junction) or within the paraspinal muscles on examination.

In general, patients with centralized low back pain most commonly have facet-mediated pain, usually due to osteoarthritis.¹⁰ Cases of refractory pain respond most appropriately to blockade of the medial branches of the spinal nerves (or the dorsal ramus when referring to L5) innervating the affected facet joints. If blockade is proven to be effective at relieving symptoms for an appropriate duration of time, radiofrequency denervation (“rhizotomy”) may be performed for more sustained relief.

Due to the unreliability of physical examination and imaging in identifying a specific cause of low back pain in most patients, percutaneous image-guided injections serve a role that is as much diagnostic as it is therapeutic. An appropriate response to targeted injection in terms of both the degree of induced analgesia and duration of the effect confirms the anatomic level responsible for a patient's symptoms. Management of back pain by percutaneous injections must therefore proceed in a stepwise fashion along an established clinical algorithm to assure accurate diagnosis and ascertain the most appropriate treatment moving forward in an overall plan of care for the patient (► Fig. 1).

Fluoroscopic-Guided Intervention

All of the procedures described in this article share some common imaging techniques and clinical features that are worthy of discussion. In general, these procedures are per-

formed in the outpatient setting and do not require sedation. To minimize risk of infectious complications, treatments should be performed under sterile conditions using drapes and an appropriate antiseptic solution for preparation of the patient's skin in the operative field.

The patient is placed in prone position on the fluoroscopy table for the intervention. Appropriate imaging landmarks are identified by first obtaining a true anteroposterior (AP) view of the lumbar spine using fluoroscopy. This is obtained by centering the spinous processes between the pedicles and aligning the vertebral body endplates in the cranial–caudal plane to provide a true en-face view of the vertebral body of interest and correct for normal lumbar lordosis. Proper visualization of bony landmarks and attention to needle trajectory are essential for procedural success.

Local anesthesia is achieved at the skin surface using 1% lidocaine, with additional deeper anesthetic administered directly through the procedural needle as needed during the intervention. Needle tip position is assessed in at least two fluoroscopic projections prior to injection. A small amount of nonionic contrast is usually administered to confirm correct positioning of the needle tip and exclude intravascular injection that may place the patient at risk for neurologic complication. Diagnostic “test” injections may consist of local anesthetic only, with the addition of corticosteroid reserved for therapeutic injections performed for more sustained relief after a confirmed appropriate clinical response to local anesthetic alone. The type and volume of injected medication varies based on the procedure being performed. Patients may experience transient reproduction or worsening of their pain symptoms during the injection;

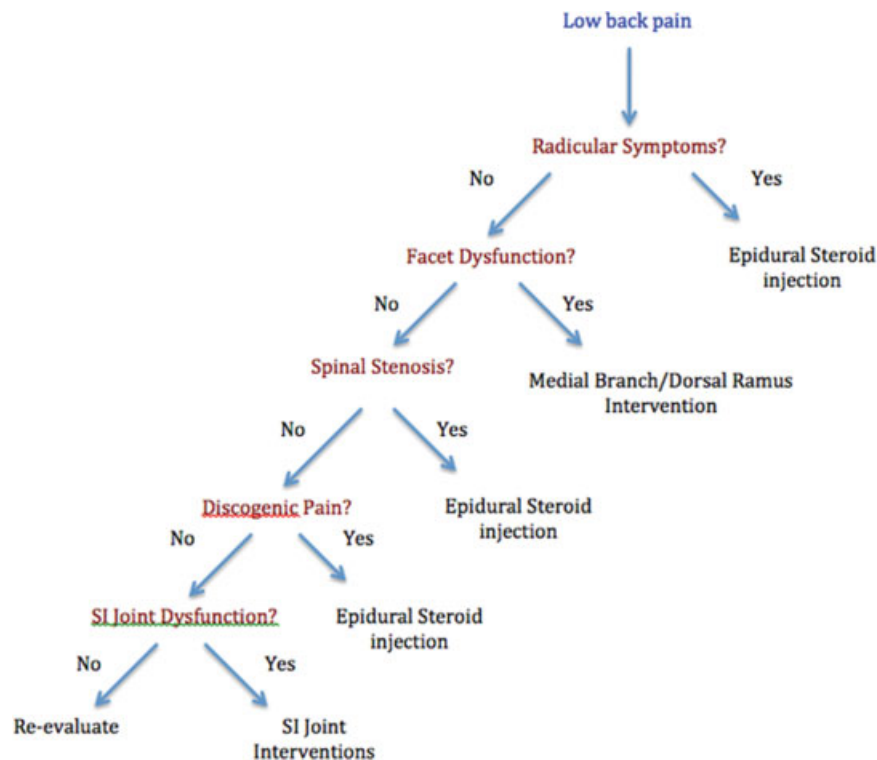


Figure 1 Clinical algorithm for the management of chronic low back pain.

however, this usually resolves within minutes after treatment; the rate at which the medication is injected can be slowed down to enhance patient comfort if necessary. Following the injection, the needle is removed and a sterile bandage applied to the skin access site.

After the procedure, the patient is placed in supine position in a recovery area for approximately 15 minutes and monitored for any side effects of motor or sensory deficits in the lower extremities. These are more commonly associated with epidural injections and are usually mild and self-limited, often resolving within 1 to 2 hours after onset. Patient discharge from the facility should be delayed until symptoms have resolved and the patient is able to ambulate without difficulty. In the authors' experience, using more than 2 to 5 mL of local anesthetic for an epidural injection is more likely to be associated with unintended blockade of the motor nerves, resulting in transient lower extremity weakness.

The analgesic effect of the local anesthetic is usually immediate, and the majority of patients will experience partial or complete pain relief within minutes. Expected duration of effect from the local anesthetic alone varies based on the type of medication administered, but typically does not persist beyond 24 to 48 hours. As the immediate effects of the local anesthetic subside, the anti-inflammatory action of any added corticosteroid begins to take effect, and patients may receive up to 3 to 6 months of sustained relief.

Epidural Steroid Injection

The main goal of ESI treatments is to deliver medication in targeted fashion as close as possible to the area of pathology to maximize therapeutic effect and minimize the systemic side effects of corticosteroid administration. The technical approach should be governed by the extent and distribution of the patient's symptoms and the underlying pathologic process felt to be responsible for the pain. Selective transforaminal epidural injection around the exiting affected nerve would be the most specific and targeted form of injection to achieve localized analgesia, and this technique is most commonly performed when an involved nerve root can be specifically determined by history or physical exam. An interlaminar approach is less selective, and may be used when a specific nerve root cannot be identified as the cause of the pain, or if it appears as though multiple nerve roots may be involved. A caudal approach using direct injection through the sacral hiatus is the least specific route of epidural steroid administration but has the lowest risk for dural puncture and intrathecal administration of medication owing to the fact that the dura terminates a considerable distance above the hiatus. Tissue within the sacral hiatus becomes more fibrotic with patient age, thereby limiting the distribution of medication injected via this route in older patients. The caudal approach is beyond the scope of this article and will not be discussed here.

Interlaminar Approach

The interlaminar approach to ESI has historically been the most common technique utilized for lumbosacral analgesia.

This approach may be performed without fluoroscopic guidance; however, the addition of imaging guidance allows more accurate delivery of the medication to the epidural space and a lower risk of procedure-related complications.¹¹

The major drawbacks of ESI using an interlaminar approach are the relatively poor distribution of medication to the ventral epidural space when compared with a targeted transforaminal approach, and the potential for dural puncture.¹² In addition, the effectiveness of this approach may be limited in patients who have had previous back surgery, as the presence of epidural scar tissue may limit the distribution of the injected medication within the region of interest. Patients with severe degenerative disc disease can also pose a technical challenge, as the interspaces between the vertebral bodies are often narrowed and the intervertebral ligaments can become densely mineralized, both of which can impede needle access to the epidural space. With proper use of fluoroscopy for imaging guidance, however, contrast may be administered prior to the steroid injection to confirm appropriate positioning of the needle tip within the epidural space, exclude dural puncture, and assess for adequate dispersion of the injectate. Many operators now feel as though ESI should be performed under fluoroscopic guidance whenever possible, and should not be attempted without imaging guidance in patients with severe documented spinal stenosis or a history of prior back surgery.¹²

Technique

Similar to the standard approach used for fluoroscopic-guided lumbar puncture, the patient is placed on the fluoroscopy table in prone position with a pillow or rolled towel placed under the abdomen to partially flex the lumbar spine. This will increase the interlaminar distance to allow a sufficient window for access to the epidural space. Using fluoroscopy, a true AP view of the lumbar spine is then obtained.

An appropriate interspace is selected for needle access to the epidural space. While this is most commonly performed at L4/5 or L5/S1, the specific level for access can be modified based on the nature of the patient's pain, with the most ideal access lying in closest proximity to the level of presumed pathology. The intended skin entry site is marked and anesthetized. A 20-gauge spinal needle or Touhy needle is then advanced en-face parallel to the fluoroscopy beam ("down the barrel") over the interlaminar space until the tip of the needle encounters slightly increased resistance as it becomes embedded in the ligamentum flavum. A lateral fluoroscopic view is then obtained to confirm that the needle tip is located within the interlaminar window, at a level immediately adjacent to the superior margin of the bony lamina. The needle stylet is removed and a syringe of sterile saline is connected to the needle hub via a short segment of extension tubing. If the needle tip is properly positioned within the ligament, there should be no ability to inject saline through the needle with gentle pressure on the plunger of the syringe. The needle is advanced into the epidural space using the "*loss of resistance technique*"—applying a continuous amount of pressure on the plunger of the saline syringe, the needle tip is slowly advanced through the ligamentum flavum until

resistance is lost and saline is able to be injected into the epidural space.¹³ Approximately 1 to 2 mL of nonionic contrast is administered through the needle to confirm appropriate positioning of the tip within the epidural space. AP and lateral views should be obtained to demonstrate relatively focal, amorphous accumulation of the contrast within the epidural space (►Fig. 2A, B). Dispersion or dilution of contrast and silhouetting of nerve roots confirms inadvertent intradural location of the needle tip. If this occurs, the needle should be completely removed and a repeat attempt at access made in a different interlaminar space to avoid inadvertent intrathecal administration of anesthetic and corticosteroid at the site of dural puncture. Some operators prefer to abort the procedure altogether once an inadvertent dural puncture is made, to preclude the above potential complications.

Once appropriate positioning of the access needle is confirmed within the epidural space on AP and lateral planes, a solution of 40 to 80 mg of triamcinolone (Kenalog) (Bristol-Myers Squibb, Princeton, NJ) mixed with 2 to 5 mL of 0.5% Marcaine (HOSPIRA, Inc., Lake Forest, IL) should be administered. Appropriate dispersion of the injectate is visualized as dilution of contrast within the epidural space during administration. Following injection, the needle is removed and a sterile bandage applied to the skin access site.

Transforaminal Approach

Transforaminal approach to ESI is typically performed for the treatment of back pain with radiculopathy conforming to a known nerve root distribution. A selective transforaminal approach allows for better delivery of a concentrated dose of medication directly to the affected nerve root, and allows for more direct access of medication to the ventral epidural space (where disc pathology is more commonly located) than more generalized interlaminar approach.¹² Although access to the epidural space via this route has many theoretical benefits over the interlaminar approach, published studies in the literature have failed to demonstrate much compelling evi-

dence of the therapeutic superiority of more targeted transforaminal injections.^{14,15} Some authors advocate for a targeted transforaminal approach in cases where there is higher risk for dural puncture with an interlaminar approach due to conditions that may diminish the reliability of the "loss of resistance" technique. Such conditions include a history of prior back surgery, soft-tissue scarring, or severe underlying spinal pathology that may significantly decrease the size of the epidural space.^{10,11}

Technique

With the patient in prone position, a true AP fluoroscopic view of the lumbar spine is obtained. The fluoroscopy beam is rotated 30 degrees in the oblique view to expose the neural foramen of interest (►Fig. 3A). The target for needle tip placement is within the superior foraminal space, just below the adjacent pedicle. A 22-gauge 3.5-inch spinal needle is bent slightly at its tip to approximate a gentle 20-degree angle opposite the direction of the needle bevel. By shaping the needle in this fashion, it may be more effectively "steered" into the foraminal space during advancement. The skin entry site is marked and anesthetized. Using the foraminal oblique view, the curved spinal needle is advanced en-face, parallel to the fluoroscopy beam to within 1 to 2 cm of the foramen (►Fig. 3B). Using the lateral view, the needle tip is slowly advanced just below the pedicle to the level of the mid-foramen (►Fig. 3C). Under real-time fluoroscopy, nonionic contrast is administered through the needle in the AP view to identify appropriate distribution proximal and distal to the needle tip along the targeted nerve root and exclude any vascular intravasation (►Fig. 3D). Contrast opacification of a radicular artery branch will usually be followed by washout once the injection is stopped, indicating that the opacified structure is vascular. If seen, the needle should be promptly removed and repositioned to avoid serious complications related to particulate embolization of the vessel by the administered corticosteroid.

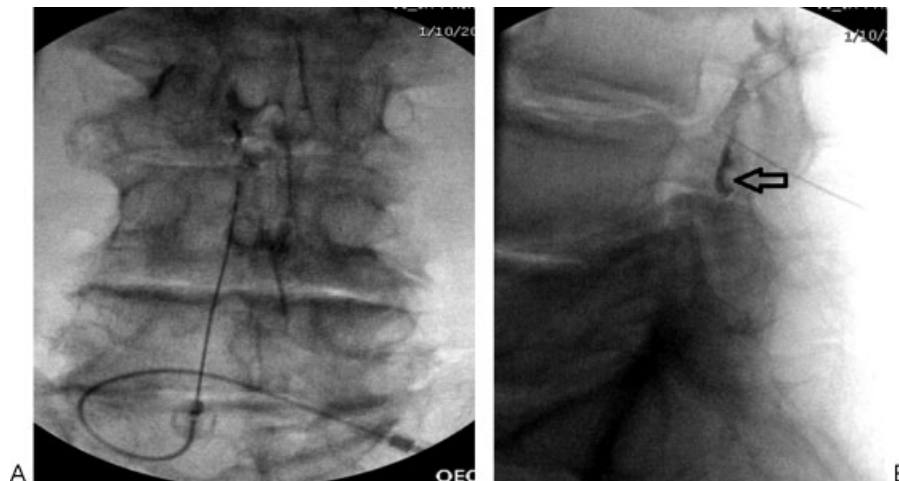


Figure 2 Interlaminar epidural steroid injection. Anteroposterior (A) and lateral (B) images of the lumbar spine showing focal distribution of contrast within the epidural space (arrow), confirming appropriate position of the needle tip prior to therapeutic injection.

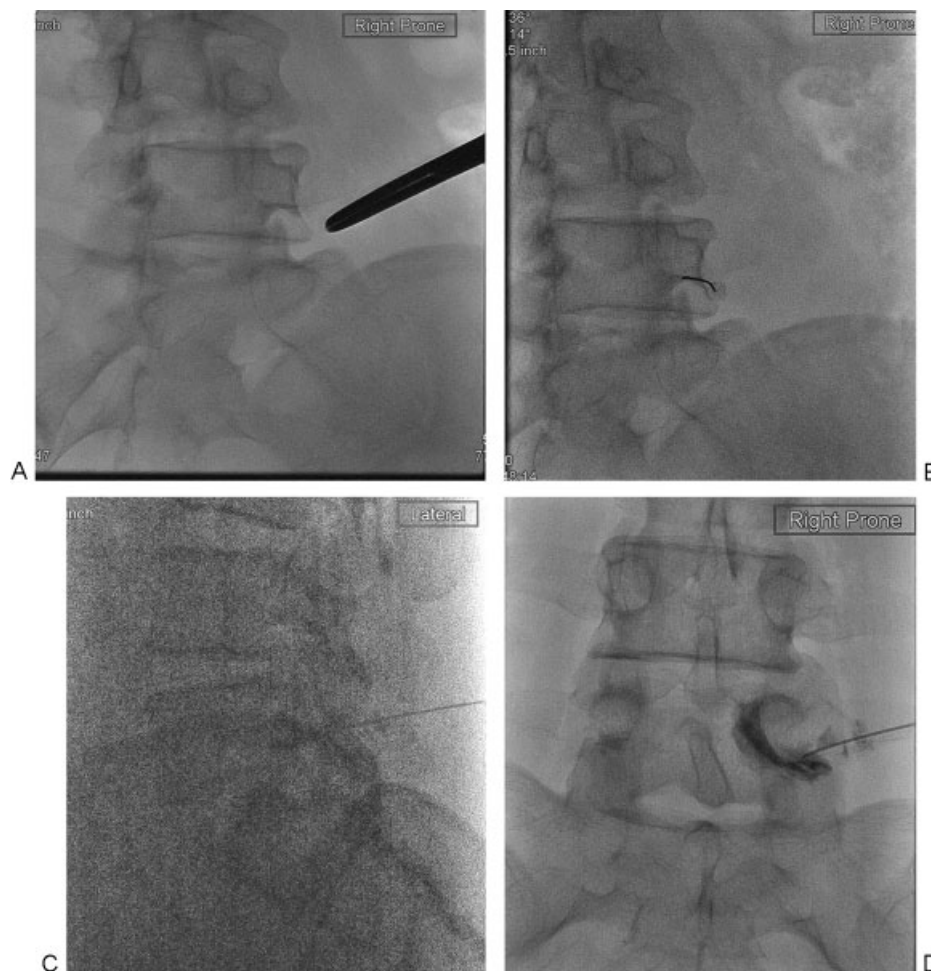


Figure 3 Transforaminal epidural steroid injection. (A) Oblique view of the lumbar spine used to identify the target right L5 foramen. (B) The curved needle is advanced en-face to target the superior aspect of the foramen, beneath the pedicle. (C) Lateral view of the lumbar spine showing appropriate placement of the needle tip within the midportion of the right L5 foramen. (D) Anteroposterior image showing focal distribution of contrast around the right L5 nerve root, tracking centrally through the foramen around the thecal sac. Real-time fluoroscopy is performed during injection to exclude intravasation of the radicular artery.

Once vascular intravasation has been excluded fluoroscopically, a concentrated mixture of 20 to 40 mg of triamcinolone (Kenalog) and 1 to 2 mL of 0.5% Marcaine is injected through the needle into the transforaminal epidural space. Adequate dispersion of the injectate is confirmed by dilution of contrast within the epidural space during administration.

A slightly modified technique is used to access the S1 foraminal epidural space. Distinguishing between the anterior and posterior sacral foramina can be difficult using fluoroscopy in the AP view. For this approach, the fluoroscopy beam is angled 30 to 45 degrees in the caudal direction to allow “open” access to the sacral foramina coming from a cephalic approach. A skin access site is selected such that the 22-gauge spinal needle is advanced en-face, parallel to the fluoroscopy beam until the needle tip contacts the posterior sacrum just below the L5/S1 facet joint. The needle tip is “walked” inferiorly in incremental fashion until it advances into the posterior S1 foramen, which is usually identified < 1 cm from the initial needle tip position. Once identified, the needle tip is further advanced through the foramen using the lateral view. Nonionic contrast is adminis-

tered to confirm epidural location of the needle tip prior to administration of the medication.

Risks and Complications

Overall, ESI using either an interlaminar or a transforaminal approach is safe and well tolerated by most patients. Reported complications are usually minor and relatively infrequent, consisting mostly of facial flushing and vasovagal reactions that occur immediately after treatment and rapidly resolve with minimal supportive care. More serious complications can occur, though they are rare. Dural puncture and inadvertent misadministration of medication into the thecal space may result in spinal anesthesia, which can cause hypotension, paralysis, and incontinence. Fortunately, these symptoms are also transient and usually only require observation and minimal supportive care. There are also reported cases of epidural hematoma and abscess formation requiring emergent surgical intervention, and emphasis should be placed on strict adherence to aseptic technique and withholding anti-coagulant and antiplatelet medications for an appropriate duration prior to the intervention.^{15,16} Spinal cord infarction

and paraplegia have been rarely reported in association with transforaminal ESI. This is felt to be a result of inadvertent injection of particulate corticosteroid into a radicular branch of the spinal artery as it courses through the foramen, which in turn may directly communicate with the anterior spinal artery. Though this complication has been most commonly reported with cervical transforaminal injections, it has also been known to occur in the lumbar region.^{15,17,18} Meticulous attention to real-time fluoroscopic imaging to exclude contrast intravasation following needle placement may help to prevent this devastating complication.

Facet Medial Branch Block and L5 Dorsal Ramus Block

Medial branch blockade is typically performed in the setting of refractory centralized lower back pain that is felt to be related to facet joint arthropathy. As previously discussed, clinical history, physical examination, and imaging findings are unreliable in establishing a diagnosis of lumbar facet syndrome in most patients, and medial branch blockade is as much a diagnostic tool as it is therapeutic in managing facet-related pain. Inflammation within the lumbar facet joints is a relatively common cause of centralized lower back pain, irrespective of the presence of imaging findings of degenerative changes within the joints themselves.

Proper technique in performing medial branch blockade depends on understanding the anatomy and sensory innervation of the facet joints. The posterior primary ramus of each lumbar spinal nerve gives rise to a medial branch, which descends over the base of the transverse process in a groove at the root of the superior articular process of the adjacent facet joint. The medial branch gives rise to afferent nerve fibers that innervate not only the adjacent facet joint capsule but also the capsule of the facet joint located at the level immediately below it (► **Fig. 4**). Thus, each facet joint receives afferent nerve fibers from the medial branch of the spinal nerve exiting at that level, as well as from the level above (i.e., the L3/L4 facet joint is innervated by the medial branch of the exiting L3 and L4 spinal nerves). The L5 spinal nerve does not have a corresponding medial branch, but instead gives rise to a dorsal ramus that passes in the groove between the sacral ala and the superior articular facet of S1.¹⁹

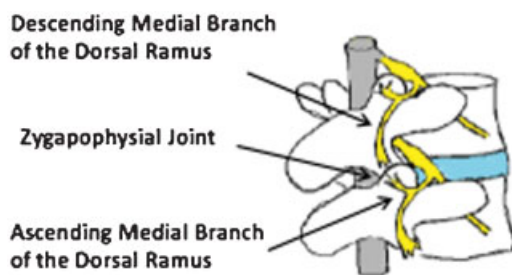


Figure 4 Innervation of the zygapophysial (facet) joints. The medial branch of each spinal nerve gives rise to afferent nerve fibers that innervate both the facet joint capsule at that level and at the level immediately below it.

Based on the neuroanatomy of the lumbar spine, complete sensory blockade of a single lumbar facet joint requires two separate injections targeting the medial branch of the exiting spinal nerve at the level of the joint and at the level immediately above. The number of facet joints to be treated is determined by the extent and distribution of the patient's pain. The most common sites for lumbar facet arthropathy are at L4/L5 and L5/S1, and this is usually bilateral.¹² In patients with centralized low back pain, blockade of the bilateral facet joints at these levels is usually sufficient to relieve pain. This is performed using a total of six separate injections (three on each side) to target the L3 and L4 medial branches and the dorsal ramus of L5 bilaterally.

Studies have shown that a high percentage of patients will have a false-positive response to medial branch blockade.^{12,20} For this reason, a positive response to two separate test injections must be documented prior to performing a therapeutic injection. Test injections are first performed with a short-acting local anesthetic such as 2% lidocaine, followed 1 week later by injection in the same locations using a longer-acting local anesthetic such as 0.5% Marcaine. A positive response to test injection is confirmed when a patient reports 50 to 80% reduction in pain level and/or the ability to perform activities that were previously considered to be painful. The duration of response to each test injection may vary between patients; however, each patient should receive an appropriate increase in duration of response between short- and long-acting anesthetic agents. In general, patients should experience a few days of relief from lidocaine test injections, and several days of relief from injections with Marcaine. If a patient has a confirmed positive response to diagnostic test injections, therapeutic injection is then performed at the same levels using a mixture of corticosteroid and long-acting local anesthetic. An appropriate dose of medication for treatment of the bilateral L4/L5 and L5/S1 facet joints (six total injections) would be 80-mg triamcinolone (Kenalog) mixed with 4 mL of 0.5% Marcaine. This would yield a total mixture volume of 6 mL, which would be administered in divided doses of 1 mL at each location.

Technique

With the patient in prone position, a true AP view of the lumbar spine is obtained. The target levels for injection are identified based on the known neuroanatomy and innervation of the facet joints as discussed previously. For a standard introductory approach to treatment of centralized low back pain, bilateral L4/L5 and L5/S1 facet joints would be treated with a total of six separate injections (three on each side) to target the L3 and L4 medial branches and the dorsal ramus of L5 bilaterally. Anatomically, these structures would be targeted at the junction of the spinous process and superior articular facet bilaterally at L4 and L5, and at the junction of the sacral ala and superior articular facet bilaterally at S1. To correctly localize the junction of the transverse process and superior articular facet at the L4 and L5 levels, the fluoroscopy beam is angled at 30 degrees of obliquity from the true AP view. The needle tip target then becomes the "eye" of the "Scotty dog," located just a few millimeters caudal to the

junction of the “ear” (superior articular process of the adjacent facet joint) and “nose” (transverse process of the associated vertebra) (►Fig. 5). The skin entry site is marked and anesthetized. A 22-gauge spinal needle is advanced en-face in this view, parallel to the fluoroscopy beam, until it contacts the bone cortex at the target site. The approach to target the dorsal ramus of L5 at the junction of the sacral ala and superior articular process of S1 is slightly different, as needle positioning and advancement at this location is performed entirely within the true AP plane. AP and lateral views are then performed to confirm appropriate positioning. A small aliquot (0.3 mL) of nonionic contrast may then be administered through the needle to assess adequate dispersion within the target region and to exclude any vascular intravasation (►Fig. 6). This is followed by administration of 0.5 to 1.0 mL of the local anesthetic test injection or anesthetic/corticosteroid therapeutic mixture. This technique is repeated on the contralateral side and at additional levels as needed.

Risks and Complications

The procedure itself is safe and very well tolerated by most patients, and there have been no serious side effects or complications reported when adhering to appropriate image-guided technique.²⁰

Radiofrequency Rhizotomy

Patients who consistently receive appropriate therapeutic response to medial branch or dorsal ramus blockade of the facet joints after 2 to 3 treatment sessions may be considered for radiofrequency (RF) denervation (rhizotomy) to provide more sustained relief. Analgesic effects of successful RF

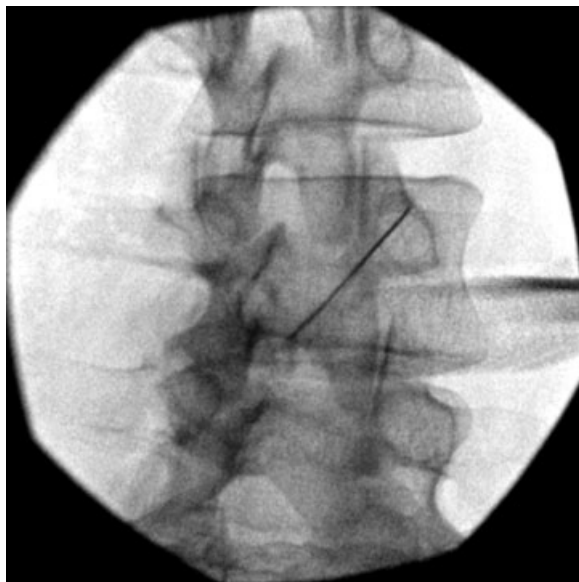


Figure 5 Targeting the medial branch of the spinal nerve. Oblique view of the lumbar spine showing appropriate needle tip position to target the medial branch of the right L3 spinal nerve. Fluoroscopic target is the junction of the transverse process and superior articular process of the facet joint (i.e., the junction between the “ear” and the “nose” of the “scotty dog”).

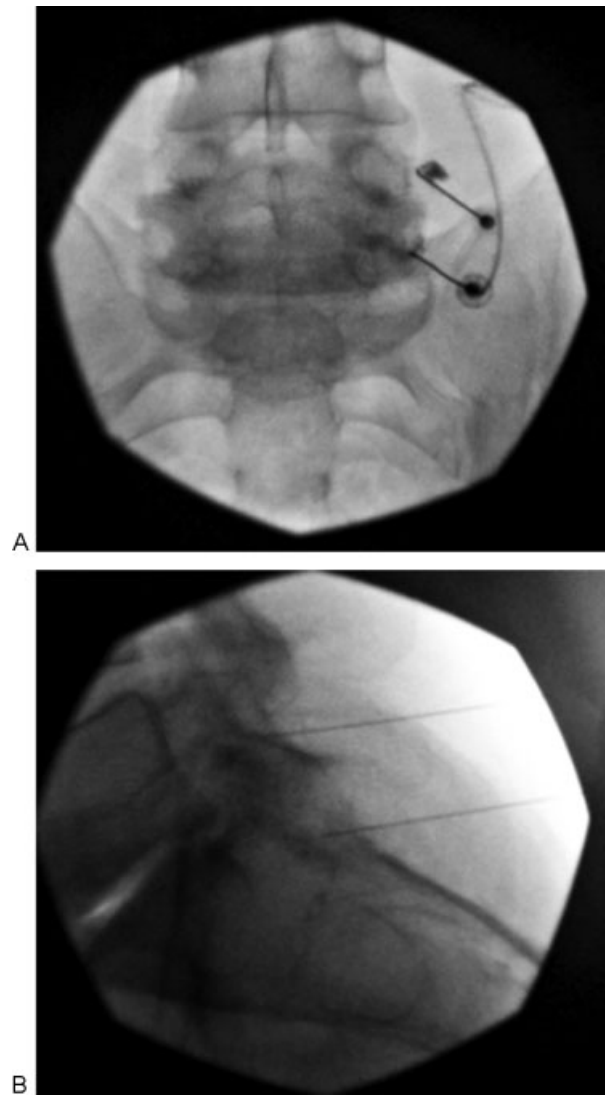


Figure 6 Medial branch block. Anteroposterior (A) and lateral (B) views showing appropriate needle tip position to target the medial branch of the right L4 spinal nerve (superior) and dorsal ramus of the right L5 spinal nerve (inferior) for sensory blockade of the right L5/S1 facet joint. Contrast disperses along the bone cortex without vascular intravasation.

rhizotomy can last up to 12 months.²¹ A detailed discussion of the physical principles behind RF denervation is beyond the scope of this article; however, this technology utilizes high-frequency electrical current to produce heat in the target tissues, resulting in thermal tissue destruction. Available devices use either continuous thermal RF or pulsed RF technology to achieve controlled destruction of nerve fibers adjacent to the tip of the electrode.²²

Technique

Fluoroscopic techniques used to target the L1–L4 medial branches and L5 dorsal rami for RF rhizotomy are similar to those previously described for performing pharmacologic analgesic blocks. However, to allow for maximum contact of the uninsulated electrode tip with the targeted nerve fibers, the skin entry site for placement of the RF electrodes

should be slightly caudal to that used for placement of the spinal needles used in pharmacologic blocks. The curved portion of the introducer needle cannula passes in a slightly cephalad direction, which should allow the RF electrode to lie in parallel to the targeted nerve fibers within the groove at the junction of the transverse process and superior articular facet (or sacral ala and superior articular facet of S1 when referring to the L5 dorsal ramus). The curved tip of the introducer cannula should be advanced within the groove no further than the level of the superior margin of the transverse process (or sacral ala) to avoid inadvertent thermal injury to the ventral ramus of the adjacent spinal nerve during treatment. True AP and lateral fluoroscopic views (technique described above) will confirm that the cannula tip is in appropriate position and does not extend too far cephalad (→Fig. 7).

The inner stylet of the introducer cannula needle is removed and approximately 1 mL of 2% lidocaine is administered for local anesthetic block of the medial branch or dorsal ramus nerve fibers during the heating process. The RF electrode is inserted through the cannula, and appropriate position is again confirmed fluoroscopically, and also using the pretreatment electrical stimulation function of the generator. Once safe positioning is confirmed, RF treatment is performed. Using the automatic mode on the generator, the temperature is set at 85°C for a treatment duration of 65 to 70 seconds. Simultaneous treatments may be performed through separate electrodes placed at other levels. Following treatment, many operators redirect the electrode 2 to 3 mm laterally and perform a second overlapping treatment to ensure adequate coverage of the targeted nerve fibers. The electrodes and introducer cannulae are removed and sterile dressings are applied to the skin access sites.

Patients commonly experience increased pain after RF rhizotomy that may persist for a few days or up to a few weeks. This can be effectively managed with temporary use of oral analgesics. Patients should be instructed to avoid heavy exertion for 1 to 2 weeks after RF rhizotomy treatment. Expected duration of analgesic effect from the procedure is approximately 8 to 12 months, and repeat treatments may be performed as necessary when pain symptoms recur.

Risks and Complications

Complications of RF rhizotomy treatment are rare if meticulous attention is given to accurate placement of the electrodes under fluoroscopic guidance. The primary risk is potential for injury to the motor nerve if the electrode tip is positioned too far anteriorly near the ventral ramus of the adjacent spinal nerve. Patients will describe a sensation of burning pain radiating down the leg if the ventral ramus is affected during RF heating. In this case, the procedure should be aborted and the needle tip repositioned to avoid any significant nerve damage.²¹

Sacroiliac Joint Injection

The sacroiliac (SI) joints have been implicated as a source of chronic lower back pain in 10 to 20% of patients.²³ SI joint pain is usually described as a dull, aching-type pain that is usually

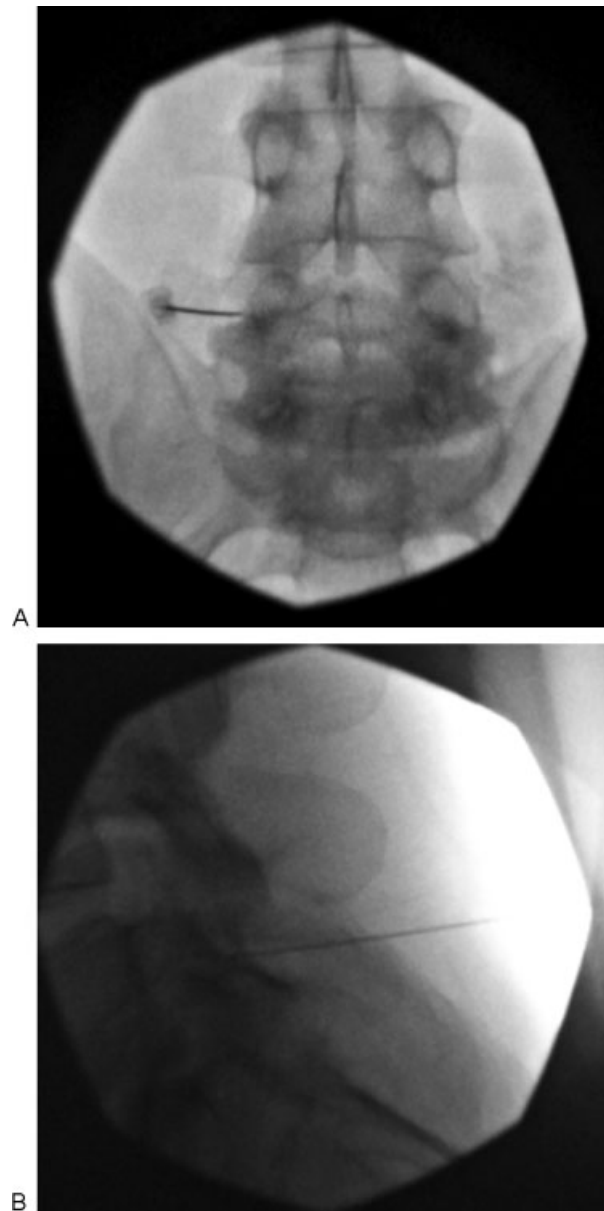


Figure 7 Radiofrequency rhizotomy. Anteroposterior (A) and lateral (B) views showing appropriate positioning of the RF electrode to target the medial branch of the left L4 spinal nerve. The electrode tip should not extend beyond the superior margin of the transverse process, so as to avoid thermal injury to the ventral (motor) ramus of the adjacent spinal nerve.

distributed over the buttock, anterolateral thigh, and groin region. It may be unilateral or bilateral, and on examination there may be tenderness to palpation over the affected joint. Symptoms of SI joint dysfunction have considerable overlap with those of facet-mediated pain, as well as with degenerative or inflammatory conditions of the hip. Although therapeutic-targeted injection of the SI joints has been described in the literature, these injections frequently fail to relieve pain or provide only temporary relief.^{23,24} Given the low prevalence of chronic lower back pain related to SI joint dysfunction and the relatively low therapeutic efficacy of percutaneous intervention, SI joint injections should be reserved as a diagnostic/

therapeutic measure of last resort in the clinical treatment algorithm, when medial branch blockade and epidural injections have been utilized with no clinical effect.

Technique

With the patient in prone position, identification of the margins of the SI joint can be difficult using fluoroscopy, as the anterior and posterior margins do not perfectly align in the AP plane due to the curved nature of the joint space. In the AP view, the posterior SI joint line projects medial to the anterior joint line. Attempts to align the joint space en-face by obliquely angulating the fluoroscopy beam may completely obscure the posterior joint line, making percutaneous access to the joint space with a needle more difficult. For this reason, it may be best to access the SI joint in the AP plane. Once the SI joint is identified, directing the fluoroscopy beam in a cephalad direction by 20 to 25 degrees can help identify the most inferior portion of the joint where the posterior joint line becomes most visible. A skin entry site is selected directly over the caudal 1 cm of the joint space. The skin is anesthetized and a 22-gauge spinal needle (straight or with a 10-degree curved tip) is advanced into the most inferior portion of the joint space with a slight degree of cephalad angulation, using the posterior joint line as a target. A change in resistance will be detected as the needle tip enters the joint space, and a small aliquot (0.5 mL) of nonionic contrast may be administered to confirm appropriate intra-articular location (►Fig. 8). Distension of the joint space with contrast may provoke or transiently increase the patient's pain level, and such a provocative maneuver may be helpful in confirming the diagnosis.²⁴ A combination of 1 mL of 0.5% Marcaine and 40-mg triamcinolone (Kenalog) is administered into the joint.

Analgesic effect should begin immediately, but it is unlikely that patients will receive a complete therapeutic response. Only 30% of patients receive $\geq 80\%$ relief, even with proper



Figure 8 Sacroiliac joint injection. Anteroposterior view showing needle access to the inferior joint space and appropriate distribution of contrast within the joint.

technique and image guidance to confirm intra-articular injection. If the patient receives $< 50\%$ reduction in pain, the intervention is considered negative from a diagnostic standpoint, and alternative etiologies for the patient's pain should be considered.^{23,24}

Risks and Complications

Overall, percutaneous injection of the SI joint under fluoroscopic guidance is a safe procedure, and is associated with only minimal risk for bleeding and infection. There have been reported cases of transient motor and sensory deficits in the ipsilateral leg soon after injection, which is felt to be related to extra-articular injection and infiltration of local anesthetic around the adjacent sciatic nerve.^{23,24}

Conclusion

Fluoroscopy-guided injection treatments for chronic refractory low back pain are safe, effective, and easy to perform interventions that may be incorporated into any existing interventional radiology practice. Serious complications from these procedures are rare; however, use of image guidance and adherence to proper technique is important to maintain their favorable risk/benefit ratio in clinical practice. The choice of injection technique should be governed by the patient's clinical history and targeted physical exam findings, and use of a simple clinical algorithm should lead to an appropriate diagnosis and plan for ongoing management.

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